第36卷 第4期
1998年 10 月

古 脊 椎 动 物 学 报
VERTEBRATA PALASIATICA

pp.282～296
figs.1～3, pls.I～II

河南淅川盆地的恐龙蛋[1)]

赵 宏 赵资奎

(中国科学院古脊椎动物与古人类研究所 北京 100044)

摘要 记述了河南淅川盆地10个地点发现的恐龙蛋化石计6种，分属于4个科6个属。其中新属1个、新种2个。新属、新种滔河扁圆蛋(*Placoolithus taohensis*)以其特有的壳单元分枝特征成为树枝蛋科的新型分子；另一新种淅川树枝蛋(*Dendroolithus xichuanensis*)与湖北安陆王店树枝蛋(*D. wandianensis*)性质相似，两者时代应彼此相当；含滔河扁圆蛋的马家村组下部应与其下含淅川树枝蛋的高沟组划归同一时段为宜，即晚白垩世早期；含副圆形蛋、椭圆形蛋、长形蛋、南雄蛋的马家村组中、上部和其上的寺沟组，时代应属晚白垩世中、晚期。

关键词 淅川盆地，晚白垩世，恐龙蛋

中图法分类号 Q915.21

1 前言

淅川(断陷)盆地位于河南省西南角，盆地北西～南东走向，长36km，宽13km，面积约420km²。盆地内晚白垩世红色地层发育，厚度可达1 600余米，由泥岩层、砾岩层、砂岩层等组成，分布于重要的水利枢纽丹江淹没区两岸。1974年，河南地质十二队报告在滔河乡朱沟村马家沟菠萝山根发现了成窝保存的恐龙蛋化石，并在此基础上将该盆地内"红层"自下而上分为包括上白垩统的三个岩组，即以粉砂岩为主的高沟组，粉砂岩及泥灰岩的马家村组以及以粉砂岩、细砂岩及泥岩组成的寺沟组及上第三系两个单元，其下覆地层为震旦系或寒武系(周世全等，1975；周世全，韩世敬，1985)。

1975年，本文后一作者曾往该地调查，在滔河(野外号7530)采集到两窝蛋化石及两个不完整的蛋化石和80余枚蛋片；1977年，周世全等再次到该盆地调查，又在其他9个地点采集到若干蛋壳化石(具体化石产地见图1)。本文仅就上述发现的材料作分类记述，并对其产出地层时代予以探讨。

2 系统描述

本文描述术语采用赵资奎(1994)和余德伟(1996)所建立的蛋壳术语方案。

---

1) 本课题得到中国科学院古生物学与古人类学科基础研究特别支持基金的资助，课题号：970107.

收稿日期：1998-03-24

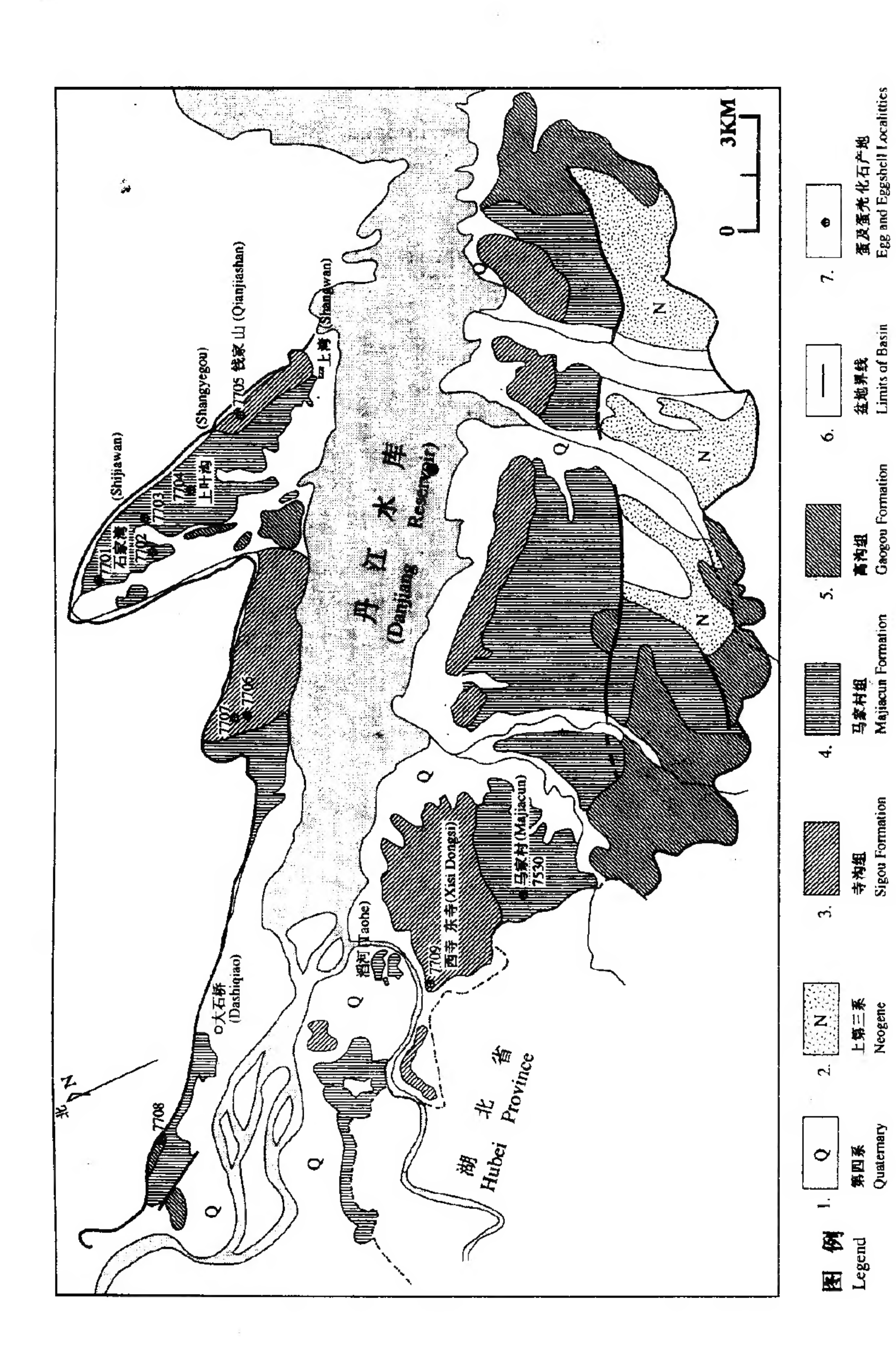


图1　淅川盆地蛋化石地点分布及地质简图(根据周世全等，1975附图修订)

Fig.1　Sketch map of Xichuan Basin showing the distribution of the fossil eggs and eggshells and lithostratigraphy (Modified from Zhou *et al.*, 1975)

树枝蛋科 Dendroolithidae Zhao et Li, 1988

修订特征 蛋化石圆形或卵圆形，蛋壳外表面较光滑，壳单元由不规则球形锥体和树枝状的柱状体组成，柱状体分枝，不对称，叉枝由内向外联合成层；气孔道阔大而不规则。

扁圆蛋属（新属）*Placoolithus* oogen. nov.

属征 见属型种“滔河扁圆蛋”种征。

滔河扁圆蛋（新属新种）*Placoolithus taohensis* oogen. et oosp. nov.

（图版 I, 1～4）

词源 plac-(G.) 扁圆盘的意思；taohe,化石产地的汉语拼音。

正型标本 一窝由九枚完整、较完整的恐龙蛋组成的蛋窝（IVPP 登记号：V11569.1；野外号：7530）。

副型标本 一窝由五个完整程度不齐的恐龙蛋组成的蛋窝（V11569.2；野外号：7530）；两个单个的蛋及 84 片碎片（V11569.3～5；野外号：7530）。

产地和层位 淅川滔河马家村，上白垩统马家村组下部。

特征 蛋近圆形，蛋窝中的蛋分布不规则。蛋壳由不完整的壳单元组成，锥体层和柱状层无明显分界；柱状体分枝，不对称，有主侧枝之分，叉枝明显小于主枝，柱状体外侧彼此连结或融合成层，该层占整个蛋壳厚度的 1／2 或柱状层厚度的 2／3；蛋壳表面气孔极少，但腔隙在蛋壳中却特别发育，并且形成阔大的通气系统。

描述 正型标本由九枚恐龙蛋组成，基本完整保存。从可测量的几个蛋化石来看（表 1），其长径在 120～134mm 之间，最大横径在 118～130mm 之间；蛋的形状指数平均为 97.6，表明这些蛋化石原来的形状基本上为圆形。蛋化石彼此间隔 3～6cm。蛋不完全在同一水平，有的蛋在窝中略有起伏，可能因原基底高低不均或因后期改造所致。副型标本由五枚恐龙蛋组成，均保存蛋的大部，但蛋形仍清晰可辨。蛋壳表面无纹饰，光滑，蛋壳厚 1.70～1.90mm。

表1 滔河扁圆蛋（V11569.1）蛋大小测量（单位：mm）

Table 1 Measurements of *Placoolithus taohensis*

编号 No.	长径 Longitudinal diameter	最大横径 Equatorial diameter	形状指数(%) Egg shape index
1	128	125	97.7
2	124	120	96.8
3	120	120	100.0
4	132	130	98.5
5	124	118	95.2
6	134	100	74.6(受挤压)
7	120	—	—

显微结构特征：蛋壳由不完整的壳单元组成，由里向外可分为锥体层和柱状层，两层

之间无明显分界。

锥体相对较为密集排列成层，厚度大约为 0.35mm，接近整个蛋壳厚度的五分之一。径切面上的单个锥体呈不规则圆形，基部向里突出，乳突位于锥体中下部，自乳突向外，楔体呈放射状扩散，锥体基部及两侧的楔体均延不远，中部的楔体一直向外延伸与柱状体连接。

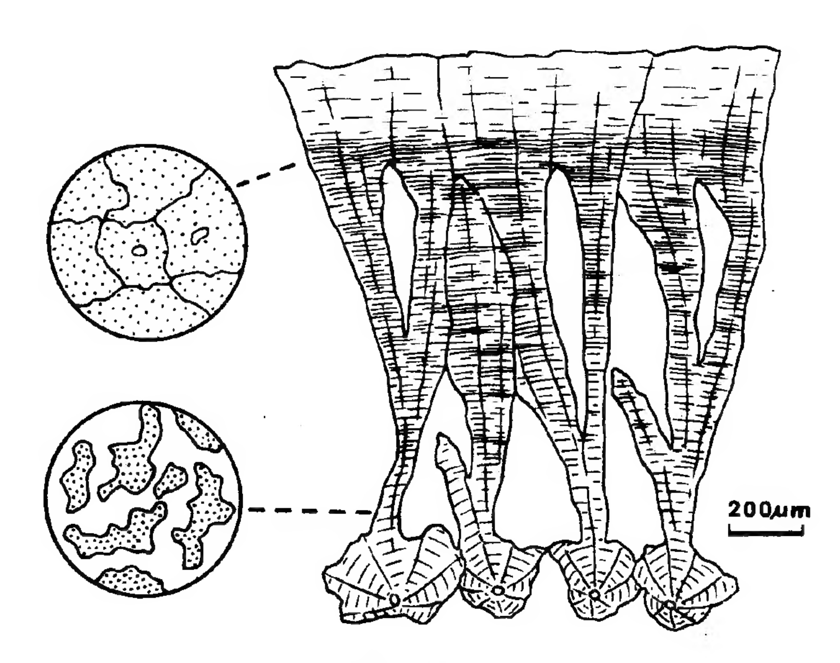


图2　滔河扁圆蛋(新属、新种)径切面素描(V11569.1)

Fig.2　Sketch diagram of the radial view of *Placoolithus taohensis* oogen. et oosp. nov.

柱状层厚 1.55mm。在径切面上，可以见到各柱状体从其相连的锥体中部向外呈分枝生长并延伸至蛋壳外表面。每个柱状体通常有 1 个主枝和 1～2 个叉枝，不对称，叉枝明显小于主枝。在距锥体层约 0.50mm 处，即由内向外在柱状体厚度的 1 / 3 处，各柱状体两侧互相连结或融合成层，厚约 1mm。分枝状的柱状体由方解石晶体组成，这些晶体由里向外呈放射状，并逐渐过渡到与蛋壳外表面成垂直方向的柱状排列，其中分布有很明显的、几乎与蛋壳外表面平行的生长纹(图版 I，2，3，图 2)。在正交偏光镜下，往往可以看出柱状体方解石晶体的消光位和它相连的锥体一致，转动物台时，柱状体呈不均一波状消光。

由于柱状体分枝而相应地形成分枝的、不规则形的空腔，因而腔隙在蛋壳中部特别发育(图版 I，2～4)，它们与锥体间隙和蛋壳外表面的气孔相连，组成一个复杂的通气系统；但是由于在近蛋壳外表面的气孔很少，平均每平方毫米只有 1～3 个气孔，因此分布在蛋壳中部的不规则形气孔道绝大多数并不直接与外界相通(这种构造特征可以较有效地防止水份过多地蒸发)，现在这些气孔道完全为次生方解石充填。

比较与讨论　河南地质十二队区研组(1974)曾将这一类型的恐龙蛋临时命名为“滔河圆形蛋”，但未给正式拉丁学名。赵资奎(1979)进一步观察认为可能为一新的恐龙蛋属，提名为扁圆蛋属(*Placoolithus*)，种名仍叫“滔河(*taohensis*)”，但未给予特征描述；后来

赵资奎(1994)将该类蛋归为树枝蛋科，种属待定。本次我们予以上述描述并将该类型蛋以"*Placoolithus taohensis*"正式命名。

赵资奎等(1988)建立的树枝蛋科，其代表属为树枝蛋属(*Dendroolithus*)，模式种为王店树枝蛋(*D. wangdianensis*)。本文描述的滔河扁圆蛋与王店树枝蛋两者表面均无纹饰，壳单元皆由不规则球形锥体和分枝状的柱状体组成；气孔道呈分枝状，在蛋壳中部特别发育，但在近外表面处，气孔数量明显减少，根据这些特征可将滔河扁圆蛋归入树枝蛋科。

然而，滔河扁圆蛋的形状指数平均为97.6，柱状体分枝一般不对称，有主干和侧枝之分，柱状体互相连结或融合成层的厚度约占柱状层厚度的 2 / 3，与王店树枝蛋相比较，差别非常明显；王店树枝蛋的形状指数为 78.1，柱状体靠近蛋壳外表面处互相连结或融合成层，大约只占柱状层厚度的 1 / 3。因此，把本文记述的滔河扁圆蛋作为树枝蛋科的一个新属种是合适的。

树枝蛋属 *Dendroolithus* Zhao and Li, 1988

修订属征 蛋卵圆形，柱状体分枝较为对称，各柱状体在近蛋壳外表面处互相连结融合成层，约占蛋壳厚度的 1 / 4，柱状层厚度的 1 / 3。

比较 本属以蛋形、分枝及柱状体融合程度不同而区别于扁圆蛋属；后者腔隙更为发达。

淅川树枝蛋(新种) *Dendroolithus xichuanensis* oosp. nov.

(图版Ⅱ，1)

词源 xichuan-,化石产地汉语拼音。

材料 蛋片 21 片(V11570;野外号 7708)。

产地和层位 淅川大石桥赵家沟，上白垩统高沟组。

种征 不完整壳单元排列松散，融合的状柱层占壳厚度的 1 / 4，第一次分枝点紧靠锥体，气腔阔大。

描述 壳厚 1.50～1.70mm，表面光滑。

显微结构特征：蛋壳由很不完整的壳单元组成。锥体间隙非常发育，锥体间距一般在0.30～0.40mm 之间。柱状体分枝并向外延伸至蛋壳外表面，但首次分枝紧靠锥体；其中一个侧枝继续分枝 1～2 次形成 3～4 个侧枝，通常侧枝短小。蛋壳柱状体之间在靠近蛋壳外表面处互相融合成层，其厚度约占柱状层厚度的 1 / 3；各柱状体之间有很大的不规则形腔隙，然而在靠近外表面处气孔数量明显减少，这种结构特征与 *Placoolithus taohensis* 和

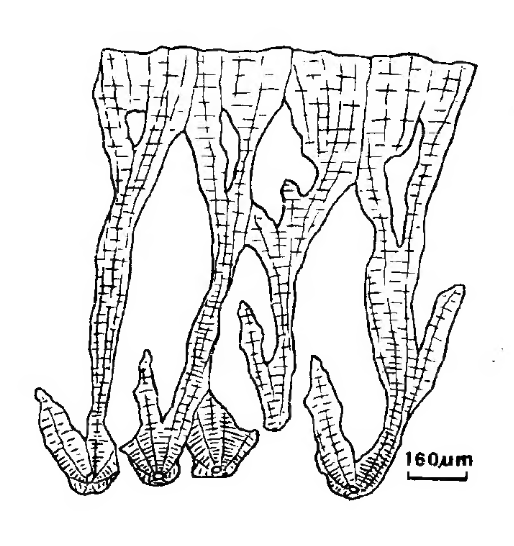


图3 淅川树枝蛋(新种)径切面素描(V11570)

Fig.3 Sketch diagram of the radial view of *Dendroolithus xichuanensis* oosp. nov.

Dendroolithus wangdianensis 相似。

比较和讨论　该类型蛋壳的柱状体首次分枝紧靠锥体，而王店树枝蛋则近壳中部；前者腔隙大而不规则，且叉枝较多，两者易于区别。

蒙古南部和东南部产于 Barun Goyot 层的两个树枝蛋种——壳表面具纹饰的疣饰树枝蛋（*D. verrucarius*）及壳表面不具纹饰的微孔树枝蛋（*D. microporosus*）（Mikhailov 1991,1994; Sabath 1991），蛋壳的变异范围均很大（前者变异范围为 2.6～3.3mm；后者为 2.0～2.7mm），其平均厚度都远较中国发现的树枝蛋分子为厚；中国发现的树枝蛋壳表面光滑。由于蒙古的两个树枝蛋种缺乏足够和清晰的图版资料，我们尚不能指出蒙古的两种树枝蛋与中国的两种树枝蛋（王店树枝蛋、淅川树枝蛋）在微观结构上的明确区分。

Mikhailov (1995) 将上述蒙古的两个树枝蛋种定为桑托尼～坎佩尼期。

圆形蛋科 Spheroolithidae Zhao, 1979

副圆形蛋属 *Paraspheroolithus* Zhao, 1979

修订属征　锥体层薄，锥体结构完整，通常 2～4 个锥体聚合在一起，形成锥体群；锥体间隙小，但锥体群之间有较明显的锥体间隙，气孔道不甚规则。

二连副圆形蛋（相似种）*Paraspheroolithus* cf. *P. irenensis* Zhao, 1979

（图版Ⅱ，2）

材料　蛋片 4 片（V11571；野外号 7702）。

产地和层位　淅川老城周家湾；上白垩统马家村组。

描述　蛋壳厚度 1.8mm，外表面具棘皮状纹饰。

显微结构特征：锥体与柱状体几乎没有分界。锥体层极薄，壳单元锥体阔锥状，常 3～4 个紧密联系在一起，锥体间隙极小，当前标本乳突大多数没有保存，内部楔体在偏光下呈明显的放射状，并直接向柱状体延伸。柱状体排列十分紧密，相邻结构单位界线极细，单偏光下观察，柱状体界限甚弱，正交镜下则易于辨认，偏光镜下转动物台，壳单元呈明显的波状消光。生长纹十分发育，并与蛋壳表面平行。

气孔道在不同的切面上呈现不同的形状：弦切面呈卵形，径向切面大多数呈蠕虫形，方位较为倾斜。

鉴定与讨论　当前标本与二连副圆形蛋模式种十分相似，只是壳单元排列更为紧密。

从上述特征看来，本文描述的淅川标本与北美蒙大拿西部上白垩统（坎佩尼期）发现的慈母龙（*Maiasaura peeblesorum*）蛋蛋壳特征非常相似，只是厚度有一定区别，二连副圆形蛋（相似种）蛋壳较厚（1.8mm），慈母龙蛋蛋壳较薄（1.0～1.2mm），它们似应为同属，即副圆形蛋属。

慈母龙（鸭嘴龙类的一种）*M. peeblesorum* 发现于北美蒙大拿的 Willow Creek Anticline 的吐・迈迪逊组（Two Medicine Formation)(Horner 和 Makela, 1979)，由于在四个蛋窝中保存有 15 个已孵化出壳的小恐龙化石，因而它们的蛋与恐龙化石的亲缘关系清楚，其蛋壳结构特征已被 Hirsch 和 Quinn(1990) 详细描述，但作者因当时尚未采用蛋化石的 Parataxonomy 分类方法，因而未给予正式命名。

Mikhailov (1994)报告了一种名叫 *Spheroolithus maiasauroides* 的恐龙蛋，这种蛋产自蒙古东部上白垩统牙道黑达组(Djadokhta Formation)，该学者认为该蛋壳纹饰与北美慈母龙蛋蛋壳非常相似，只是纹饰略显细微，蛋个体略小，蛋壳厚度有一定差别(1.2～1.5mm)，但 Mikhailov 在关于 *S. maiasauroides*"比较"部分中所提到的二连圆形蛋(*S. irenensis*)，实际已是一个废弃的名字，它已由原作者从圆形蛋(*Spheroolithus*)中分离出来，单独建立一个新属——副圆形蛋属(*Paraspheroolithus*)，模式种为二连副圆形蛋(*P. irenensis*)(Zhao,1979)。Mikhailov (1994)所描述的 *S. maiasauroides* 既然与慈母龙蛋壳特征相近，因此，我们有理由认为 *S.maiasauroides* 可能也应属于副圆形蛋。

值得注意的是圆形蛋和副圆形蛋是两个独立的属。圆形蛋最明显的特征是：锥体不太完整，蛋壳锥体之间彼此明显分开，并形成显著的锥体间隙，锥体由不完整的楔组成，有明显楔间隙(赵资奎，1979；Zhao,1993,1994)；而副圆形蛋则不同，锥体层薄，锥体较完整，锥体的排列一般是二至四个成群地聚集在一起，锥体间隙通常很小，只是锥体群之间才有较明显的锥体间隙，此外，锥体中没有楔间隙。

椭圆蛋科 Ovaloolithidae Mikhailov, 1991

椭圆蛋属 *Ovaloolithus* Zhao, 1979

金刚口椭圆形蛋 *Ovaloolithus chinkangkouensis* Zhao,1979

(图版Ⅱ，3～4)

材料 野外号 7701 地点蛋片 7 片，7706 地点蛋片 3 片；V11572，V11573。

产地和层位 淅川老城石家湾、尖坊沟八里岗；上白垩统马家村组～寺沟组。

描述 蛋壳厚 1.65mm，表面具密集不规则的瘤蠕饰。

显微结构特征：锥体层极薄，当前标本多遭受侵蚀(图版Ⅱ，4)；柱状层厚，根据柱状体排列形式可将其分为内带和外带(图版Ⅱ，3，4)。

内带厚 0.64mm，各柱状体柱状排列，彼此界线清晰，并具明显生长纹。

外带厚 0.94mm，柱状体之间界线不明显，由内带向外呈放射状交错排列。在光学显微镜下，外带具有明显的深色和浅色条纹(图版Ⅱ，3)。

长形蛋科 Elongatoolithidae Zhao, 1975

长形蛋属 *Elongatoolithus* Zhao, 1975

长形蛋(未定种) *Elongatoolithus* oosp.

(图版Ⅱ，5)

材料 野外号 7704 地点蛋片 4 片、7705 地点蛋片 7 片，7707 地点蛋片 15 片，7709 地点蛋片 2 片；V11574.1～2，V11575.1～2。

产地和层位 淅川老城王沟、老城钱家山上叶沟、老城大沟、滔河乡朱家山凤凰头；上白垩统马家村组～寺沟组。

描述 壳薄，厚约 1mm，表面具瘤状纹饰或细脊。

显微结构特征：锥体层厚 0.18mm，锥体呈短圆锥状，排列连续紧密，乳突由内向外作放射状，锥体内横向生长纹稀少，高度起伏不一；柱状层厚 0.74mm，层状并呈波浪起伏，层

内由小的块状方解石晶体组成,内部细密的横向生长纹起伏与锥体高度及蛋壳表面起伏一致,锥体与柱状体之比为1:4。

从上述特征来看,这些蛋壳碎片与已知的安氏长形蛋(*E. andrewensis*)和长形长形蛋(*E. elongatus*)都有一定相似,由于材料较少,保存不佳,难于进一步对比。

南雄蛋属 *Nanhsiungoolithus* Zhao, 1975

主田南雄蛋 *Nanhsiungoolithus chuetienensis* Zhao, 1975

(图版II, 6)

材料　蛋片8片(V11576;野外号:7703)。

产地和层位　淅川老城四路沟东; 上白垩统马家村组。

描述　蛋壳极薄,约0.6~0.8mm,表面极其光滑。

显微结构特征:锥体层薄,约0.15mm。锥体阔锥状,乳突位于锥体底部正中处,楔体呈对称的放射状,其上有较均匀排布的弧状生长纹。

柱状层厚约0.65mm,两侧界线略为折曲,在不同部位清晰或否,生长纹呈起伏不大的波状,在柱状层中下部较为致密,上部较疏。

气孔道呈裂隙状。

3　淅川盆地恐龙蛋面貌及其地层时代

经鉴定淅川盆地恐龙蛋分子如下:

寺沟组: 长形蛋(未定种) (*Elongatoolithus* oosp.);
金刚口椭圆形蛋 (*Ovaloolithus chinkangkouensis*);

马家村组: 长形蛋(未定种) (*Elongatoolithus* oosp.);
主田南雄蛋 (*Nanhsiungoolithus chuetienensis*);
金刚口椭圆形蛋 (*Ovaloolithus chinkangkouensis*);
二连副圆形蛋(相似种) (*Paraspheroolithus* cf. *P. irenensis*);
滔河扁圆蛋(新属、新种) (*Placoolithus taohensis* oogen. et oosp. nov.);

高沟组: 淅川树枝蛋(新种) (*Dendroolithus xichuanensis* oosp. nov.)。

在中国,根据目前的记录,树枝蛋类分子共二种,即王店树枝蛋和淅川树枝蛋;王店树枝蛋见于湖北安陆公安寨组下部,时代属于晚白垩世早期(赵资奎等,1988),由于淅川树枝蛋与湖北安陆的王店树枝蛋性质相近,因而两者层位可能相当,时代相近;又由于滔河扁圆蛋是树枝蛋科的新型分子,故我们认为含滔河扁圆蛋的马家村组下部应与其下含淅川树枝蛋的高沟组划归同一时段为宜,即晚白垩世早期;产于桑托尼~坎佩尼期蒙古的树枝蛋与中国的相比差别较大,时代上有可能存在着一定的差异。

其他类型的恐龙蛋,如:副圆形蛋在山东王氏群中、上部均有发现(主要集中在中部),时代相当于晚白垩世早中期(Zhao, 1994);在蒙古可能出现于南部的牙道黑达组,层位相当于桑托尼~坎佩尼期,在北美出现在吐·迈迪逊组,层位相当于坎佩尼期(见二连副圆

形蛋相似种"鉴定与讨论")。椭圆形蛋在山东莱阳的王氏群上部、南雄盆地的南雄群、蒙古的牙道黑达组都有发现；主田南雄蛋以前只见于南雄群中。因而我们认为含滔河扁圆蛋层位之上的马家村组中、上部及其上的寺沟组时代应为晚白垩世中、晚期。

致谢 在本文研究过程中承蒙段雨霞指导制作镜检标本；欧阳涟、张文定、张杰摄制有关照片，沈文龙先生清绘插图，在此表示感谢。

参 考 文 献

佘德伟，1995．卵壳的超微结构特征．动物学报，41(3)：243～252

河南省地质局地质十二队区研组，1974．我省首次发现恐龙蛋化石．河南地质科技情报，(7)：67～70

周世全，韩世敬，张永才，1975．河南淅川盆地中新生代"红色"地层．中南地质科技情报，(3)：65～71

周世全，韩世敬，1985．河南淅川盆地晚白垩世地层的新材料．河南地质，3(2)：35～37

赵资奎，1975．广东南雄恐龙蛋化石的显微结构(一)——兼论恐龙蛋化石的分类问题．古脊椎动物与古人类，13(2)：105～117

赵资奎，1979．我国恐龙蛋化石研究进展．华南中、新生代红层——广东南雄"华南白垩纪～早第三纪红层现场会议"论文集．北京：科学出版社．330～340

赵资奎，蒋元凯，1974．山东莱阳恐龙蛋化石的显微结构研究．中国科学，1：63～72

赵资奎，黎作聪，1988．湖北安陆新的恐龙蛋类型的发现及其意义．古脊椎动物学报，26(2)：107～115

赵资奎，叶 捷，李华梅等，1991．广东南雄盆地白垩系～第三系交界恐龙绝灭问题．古脊椎动物学报，129(1)：1～20

Hirsch K F, Quinn B, 1990. Eggs and eggshell fragments from the Upper Cretaceous Two Medicine Formation of Montana. *J Vertebr Paleontol*, 10(4): 491～511

Horner J R, Makela R, 1979. Nest of juveniles provides evidence of family structure among dinosaurs. *Nature*, 82: 296～298

Mikhailov K E, 1991. Classification of fossil eggshells of amniotic vertebrates. *Acta Palaeont Pol*, 36: 193～238

Mikhailov K E, 1994. Eggs of sauropod and ornithopod dinosaurs from the Cretaceous deposits of Mongolia. *Paleontol J*, 28: 141～159

Mikhailov K E, 1995. Systematic, faunistic and stratigraphic diversity of Cretaceous eggs in Mongolia: comparison with China. In: Sun A L, Wang Y Q eds. Sixth Symposium on Mesozoic Terrestrial Ecosystems and Biota, Short Papers. Beijing: China Ocean Press. 165～168

Sabath K, 1991. Upper Cretaceous amniotic eggs from the Gobi Desert. *Acta Palaeont Pol*, 36: 151～192

Zhao Z K, 1993. Structure, formation, and evolutionary trends of dinosaur eggshell. In: Kobayashi I, Mutvei H, Sahni A eds. Structure, Formation and Evolution of Fossil Hard Tissues. Tokyo: Tokai Univ. Press. 195～212

Zhao Z K, 1994. The dinosaur eggs in China: on the structure and evolution of eggshells. In: Carpenter K, Hirsch K F, Horner J R eds. Dinosaur Eggs and Babies. Cambridge: Cambridge University Press. 184～203

DINOSAUR EGGS FROM XICHUAN BASIN, HENAN PROVINCE

ZHAO Hong　　ZHAO Zikui

(*Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences* Beijing 100044)

Key words　Xichuan Basin, Late Cretaceous, dinosaur egg

Summary

Xichuan Basin, located in the southwest of Henan Province, is an elongated basin with its longitudinal axis oriented in the northwest～southeast direction. The "red–beds" unconformably deposited on the Precambrian or Cambrian rocks are widely distributed in the basin, with a maximum thickness of over 1600m. In 1974, Upper Cretaceous dinosaur eggs were first discovered in these beds by the Twelfth Geological Brigade, Bureau of Geology and Mineral Resources of Henan, and the egg–bearing beds were divided into three formations: Gaogou, Majiacun, and Sigou formations.

After this discovery, the latter author surveyed the area, and collected two clutches of eggs and many eggshell fragments in 1975. Two years later, the Twelfth Geological Brigade collected many eggshell fragments from 9 localities (Fig. 1). In this paper, we characterize the dinosaur eggshell assemblages from 10 localities in the Xichuan Basin and discuss the ages of the egg–bearing beds.

Systematic Paleontology

Dendroolithidae Zhao et Li, 1988

Revised diagnosis Eggs, spherical or oval. Outer surface smooth. Basic structural units consisting of nearly spherical cones and branch–like column. Column branching asymmetrically and interlocking. Pore canals very large and irregular.

***Placoolithus* oogen. nov.**

Diagnosis See the diagnosis of *Placoolithus taohensis* oogen. et oosp. nov.

***Placoolithus taohensis* oogen. et oosp. nov.**

(Plate I, 1～4)

Etymology plac–(Greek), meaning plate; taohe, in reference to the locality where the specimens were collected.

Holotype A nest with 9 eggs (IVPP V11569.1; Field No. 7530).

Referred material A nest with 5 eggs more or less compressed (V11569.2; Field No. 7530); Two eggs and 84 eggshell fragments (V11569.3～5; Field No. 7530).

Locality and horizon Majiacun, Taohe, Xichuan; Upper Cretaceous, Majiacun Formation.

Diagnosis Eggs nearly spherical and disposed at random in the nest. Eggshells consisting of incomplete basic structure units. No obvious mark between cone layer and columnar layer. Columns branching asymmetrically. Outer parts of the columns connecting or interlocking, forming a continuous layer taking up 1 / 2 eggshell thickness or 2 / 3 columnar height. Few pores on their outer surface. Pore canals very developed, causing a big complex pore system.

Description The measurements of the holotype specimen are listed in Table 1. The eggs are 120～134mm long and 118～130mm wide. Their average shape index is 97.6, suggesting the nearly circular contour. The eggs within the nest are separated from each other at a distance of 3～6 cm. Each egg is at the same horizon with some undulation. The nest of referred material consists of 5 eggs, all of which are incomplete, with more than half preserved, but their contour is still observable. The eggshell is smooth on the outer surface, and its thickness is 1.70～1.90mm.

The eggshell of this oospecies is composed of incomplete basic structural units. The transition between the cone layer and the columnar layer is gradual. The cone layer is 0.35mm thick, one-fifth or less of the eggshell thickness. The cone is irregularly spherical in shape, with its base protruding inward. The columnar layer is 1.55mm thick. Each column has a main branch and 1～2 asymmetrical secondary branches that tend to interlock at their lateral boundaries at the level of 1 / 3 of the column height from the inner side, forming a continuous layer in the other 2 / 3 columnar height (Plate I, 2, 3; Fig. 2). The growth lines are well preserved, and nearly parallel to egg surface (Plate I, 2, 3). The pore canals are very developed (Plate I, 2～4). They are originated in the inter-cone spaces, expanding in diameter and branching at their middle part to form a labyrinth. However, only a small number of them (1～3 per sq. mm) perforate the outer surface. The pore canals are entirely choked with calcite due to the secondary mineralization.

Comparison and discussion Although a preliminary description of these eggs from the Xichuan Basin was provided by the Twelfth Geological Brigade of Henan in 1974, formal Latin nomenclature has not yet been established. Zhao (1979) made observations on the microstructure of these eggshells and believed that they represent a new form to which he assigned the name *Placoolithus taohensis*. However, he did not give any description at that time. Afterwards, Zhao (1994) assigned them to Dendroolithidae, but he did not suggest the oogenus and oospecies. We now therefore

provide the above description and make both the oogenus and oospecies names formal.

The above eggs and eggshells can be referred to the family Dendroolithidae that was erected on the basis of eggs *Dendroolithus wangdianensis* from the Upper Cretaceous Gong'anzhai Formation, Hubei Province (Zhao and Li, 1988). The eggs from the Xichuan Basin differ from *D. wangdianensis* in the shape of eggs, and characters of columnar layer. For the latter species, eggs are oval, 145~162mm wide and 170~210mm long; the shape index is 70~84; the columns in the columnar layer tend to interlock at their lateral boundaries at the level of near 2/3 of the column height from the inner side, forming a continuous layer in the other 1/3 columnar height. These differences strongly suggest that the above described eggs and eggshells from Xichuan Basin represent a new oogenus.

Dendroolithus Zhao and Li, 1988

Revised diagnosis Eggs oval. Column branching symmetrically. Columns interlocking near the outer surface of the eggshell, forming a continuous layer. The layer taking up 1/4 eggshell thickness or 1/3 columnar height.

Comparison This genus differs from *Placoolithus taohensis* in shape, branching style and height of interlocking columnar layer. In addition, the latter has much bigger pore canals than the former.

Dendroolithus xichuanensis oosp. nov.

(Plate II, 1)

Etymology xichuan-, in reference to the locality where the fossil eggs were collected.

Holotype 21 eggshell fragments (V11570; Field No. 7708)

Locality and horizon Zhaojiagou, Dashiqiao, Xichuan; Upper Cretaceous, Gaogou Formation.

Diagnosis Incomplete shell units loosely arranged. Continuous interlocking layer of the column taking up 1/4 eggshell thickness. The point of the first split of the columnar layer closely near its cone. Pore canal largely expanded.

Description The eggshell is 1.50~1.70mm thick. The outer surface is smooth. The incomplete shell units are loosely arranged, and tend to interlock at their lateral boundaries at the level of about 2/3 of the shell unit height from the inner side. The inter-cone spaces are well-developed. The intervals among the cones are 0.30~0.40mm. Closely near its cone does each shell unit first split up into two branches, and one of the two branches repeats split one to two times more toward outer surface like a tree. The pore canals are largely expanded and branched at their middle part.

Comparison and discussion This oospecies is very close to *D. wangdianensis* in

the characters of columnar layer. The difference between these two mainly lies in the first branching position of the shell unit. In *D. xichuanensis*, the shell unit first branches closely near its cone, whereas *D. wangdianensis* has its first branch near its middle position.

D. verrucarius and *D. microporosus* (Mikhailov 1991, 1994; Sabath 1991) in southern and southeastern Mongolia differ from the Chinese elements of *Dendroolithus* —*D. xichuanensis* and *D. wandianesnis* —in variations of shell thickness and other measurable data. Due to few micrographs being clearly discernible, we think it is better for us not to tell their ultra-structure difference so far.

Spheroolithidae Zhao, 1979

***Paraspheroolithus* Zhao, 1979**

Revised oogenus diagnosis Cone nearly complete. Two or more cones gathering into groups. Interstices between cones extremely small. Gaps between two cone groups noticeable. Pore canals irregular to some extent.

***Paraspherootithus* cf. *P. irenensis* Zhao 1979**

(Plate II, 2)

Holotype 4 eggshell fragments (V11571; Field No. 7702)

Locality and horizon Zhoujiawan, Laocheng, Xichuan; Upper Cretaceous, Gaogou Formation.

Description The eggshell is 1.8mm thick in average. The outer surface bears weak sagenotuberculate ornament. Each shell unit has no pronounced boundaries with the adjacent units. The cone layer is very thin. Generally, 3～4 cones gather together. The interstices between cones are small. Most mammilla of the described specimen are not preserved. Cunei of the cones radiate obviously and extend into column. The pore canals are irregular, often changing their routes.

Comparison and discussion This oospecies is quite similar to the eggs of *Maiasaura peeblesorum* (Hirsch and Quinn, 1990) in shell structure. However, they have different eggshell thickness. The eggshell of *P.* cf. *P. irenensis* is significantly thicker than that of *M. peeblesorum* (1.0～1.2mm). *M. peeblesorum* was described by Horner and Makela (1979) as hadrosaurid based on fifteen identifiable hatchlings found in the Two Medicine Formation of Montana. Their eggs and eggshells were described but not parataxonomically assigned by Hirsch and Quinn (1990). We suggest that the two oospecies should belong in the same oogenus, namely *Paraspheroolithus*.

Mikhailov (1994) reported some eggshells of an oospecies, *Spheroolithus maiasauroides*, which were collected from the Upper Cretaceous Djadokhta Formation, eastern Gobi of Mongolia. He described that the ornament of the outer surface of *S. maiasauroides* is similar to that of eggshells of *Maiasaura*, but it differs from the

latter in "'fine' sagenotuberculate ornament, size of eggs, and, probably, their shorter form". In consideration of some similar characters between *S. maiasauroides* and eggshell of *M. peeblesorum*, it seems advisable that *S. maiasauroides* belong in the oogenus of *Paraspheroolithus*. Mikhailov also compared *S. maiasauroides* with *S. irenensis*, however, it should be noticed that *S. irenensis* had been moved out from *Spheroolithus* into *Paraspheroolithus irenensis* (Zhao, 1979). The two genera, *Paraspheroolithus* and *Spheroolithus* can be distinguished from each other in microstructure and ultra-structure of the eggshell units. In *Spheroolithus*, the cone is apparently irregular in shape, and fairly isolated at its origin, so noticeable spaces remain between the cones. The cunei of each cone are not compressed together, and inter-cuneate spaces occur between the cunei (Zhao, 1979; Zhao, 1993, 1994). The eggshell of *Paraspheroolithus* is composed of complete shell units. The cones are often gathered at two to four. The cunei of each cone are compressed together without inter-cuneate space.

Ovaloolithidae Mikhailov, 1991

***Ovaloolithus* Zhao, 1979**

***Ovaloolithus chinkangkouensis* Zhao, 1979**

(Plate Ⅱ, 3~4)

Holotype 7 eggshell fragments in Locality 7701, 3 eggshell fragments in Locality 7706; V11572, V11573.

Locality and horizon Shijiawan, Laocheng, and Baligang, Jianfanggou, Xichuan, Upper Cretaceous, Majiacun Formation~Sigou Formation.

Description The eggshell thickness is 1.65mm. Irregular worm-like nods are present on the outer surface. The cone layer is exceedingly thin and evidently erosive. The columnar layer is thicker. The inner zone and outer one can be recognized on the basis of the arrangement of column (Plate Ⅱ, 3, 4). The inner zone is 0.64mm thick. The columns clearly separated each other are arranged in columnar pattern with apparent growth lines. The outer zone is 0.94mm thick. The columns interlock radiantly. The boundaries between columns are unclear. Under the polarized light, columnar striates of the outer zone have different shades (Plate Ⅱ,3).

Elongatoolithidae Zhao, 1975

***Elongatoolithus* Zhao, 1975**

***Elongatoolithus* oosp.**

(Plate Ⅱ, 5)

Holotype 4 eggshell fragments in Locality 7704, 7 eggshell fragments in Locality 7705, 15 eggshell fragments in Locality 7707, 2 eggshell fragments in Locality 7709;

V11574.1～2, V11575.1～2.

Locality and horizon Wanggou, Laocheng, Xichuan; Shangyegou, Qianjiashan, Laocheng, Xichuan; Dagou Laocheng, Xichuan; Fenghuangtou, Chujiashan, Taohe, Xichuan; Upper Cretaceous, Majiacun～Sigou Formation.

Description The cone layer is 0.18mm thick.

The columnar layer shows an undulating sublayer, roughly parallel to the outer surface of the eggshell. The ratio of the cone to column is 1:4.

***Nanhsiungoolithus* Zhao, 1975**

***Nanhsiungoolithus chuetienensis* Zhao, 1975**

(Plate Ⅱ, 6)

Material 8 eggshell fragments (V11576; Field No. 7703).

Locality and horizon Eastern Silugou, Laochen, Xichuan, Majiacun Formation.

Description Eggshells are very thin and smooth on the outer surface. The thickness of the eggshell is between 0.6～0.8mm. The cone layer is 0.15mm. The cone is broadly conical. The cunei of each cone present symmetrical radiation with arched growth lines. The columnar layer is about 0.65mm. Its margins are distinct or otherwise in different position. The growth lines are undulated, scanty at the middle level upward but thick below. The pore canals are slit-like.

From the present study it is clear that there are 6 oospecies belonging to 6 oogenera of 4 oofamilies from Xichuan Basin. Based on the stratigraphical levels of these oospecies, two assemblages can be recognized: the lower one, including *Dendroolithus xichuanensis* oosp. nov. and *Placoolithus taohensis* oogen. et oosp. nov. from the Gaogou Formation and the lower part of Majiacun Fomation, and the upper one, composed of *Paraspheroolithus* cf. *P. irenensis*, *Ovaloolithus chinkangkouensis*, *Nanhsiungoolithus chuetienensis* and *Elongatoolithus* oosp. from the middle and upper part of Majiacun Formation and Sigou Formation.

图版说明(Explanations of plates)

图版Ⅰ(Plate Ⅰ)

1～4 淅河扁圆蛋(新属、新种) (*Placoolithus taohensis* oogen. et oosp. nov.), IVPP V11569.1

1. 有9枚近乎完整的蛋化石一窝 A nest with 9 eggs; 2. 蛋壳径切面 radial view, SEM, No. 75030; 3. 蛋壳径切面(单偏光) radial view, not polarized; 4. 蛋壳近锥体层处柱状层的弦切面(单偏光下) tangential section through the columnar layer, cutting across near the cone layer, not polarized

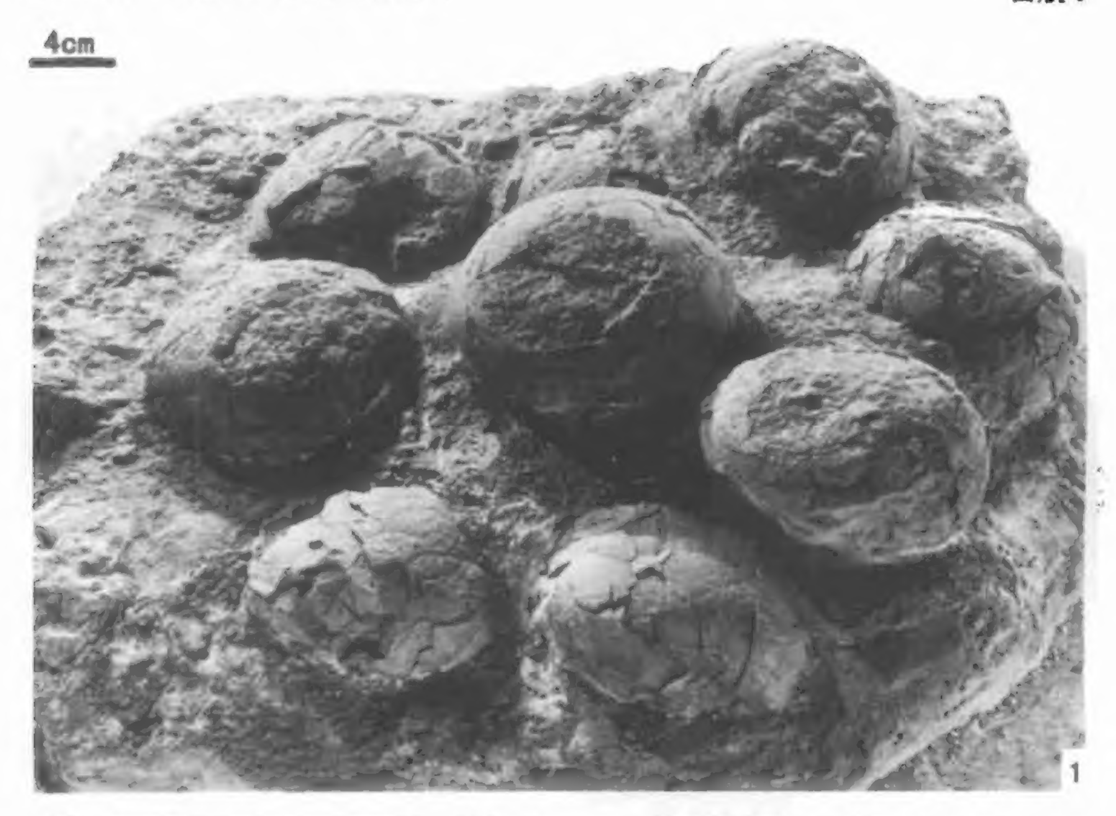
图版Ⅱ(Plate Ⅱ)

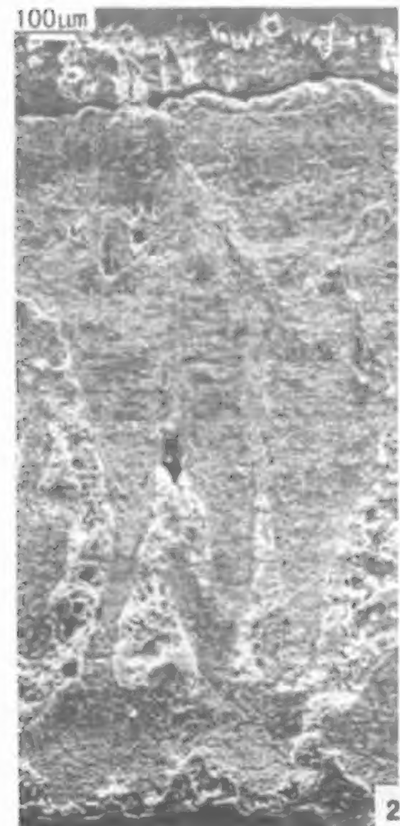
1. 淅川树枝蛋(新种) (*Dendroolithus xichuanensis* oosp. nov.) 径切面 radial view, SEM, IVPP V11570

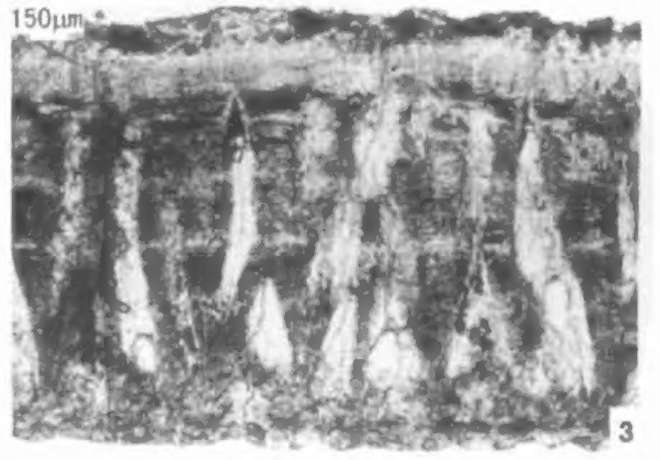
2. 二连副圆形蛋(相似种) (*Paraspheroolithus* cf. *P. irenensis*) 径切面(单偏光) radial view, not polarized, V11571

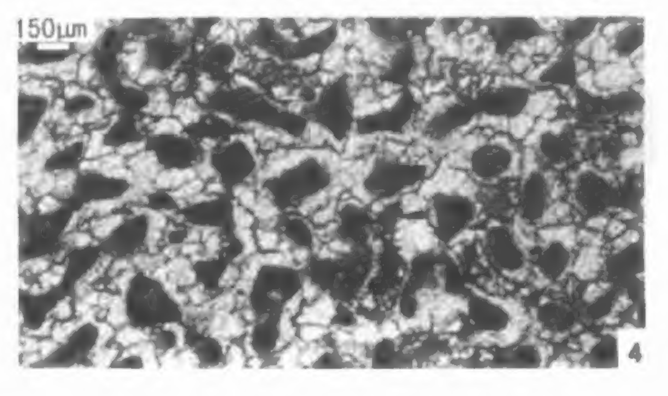
3～4 金刚口椭圆形蛋(*Ovaloolithus chinkangkouensis*), V11572

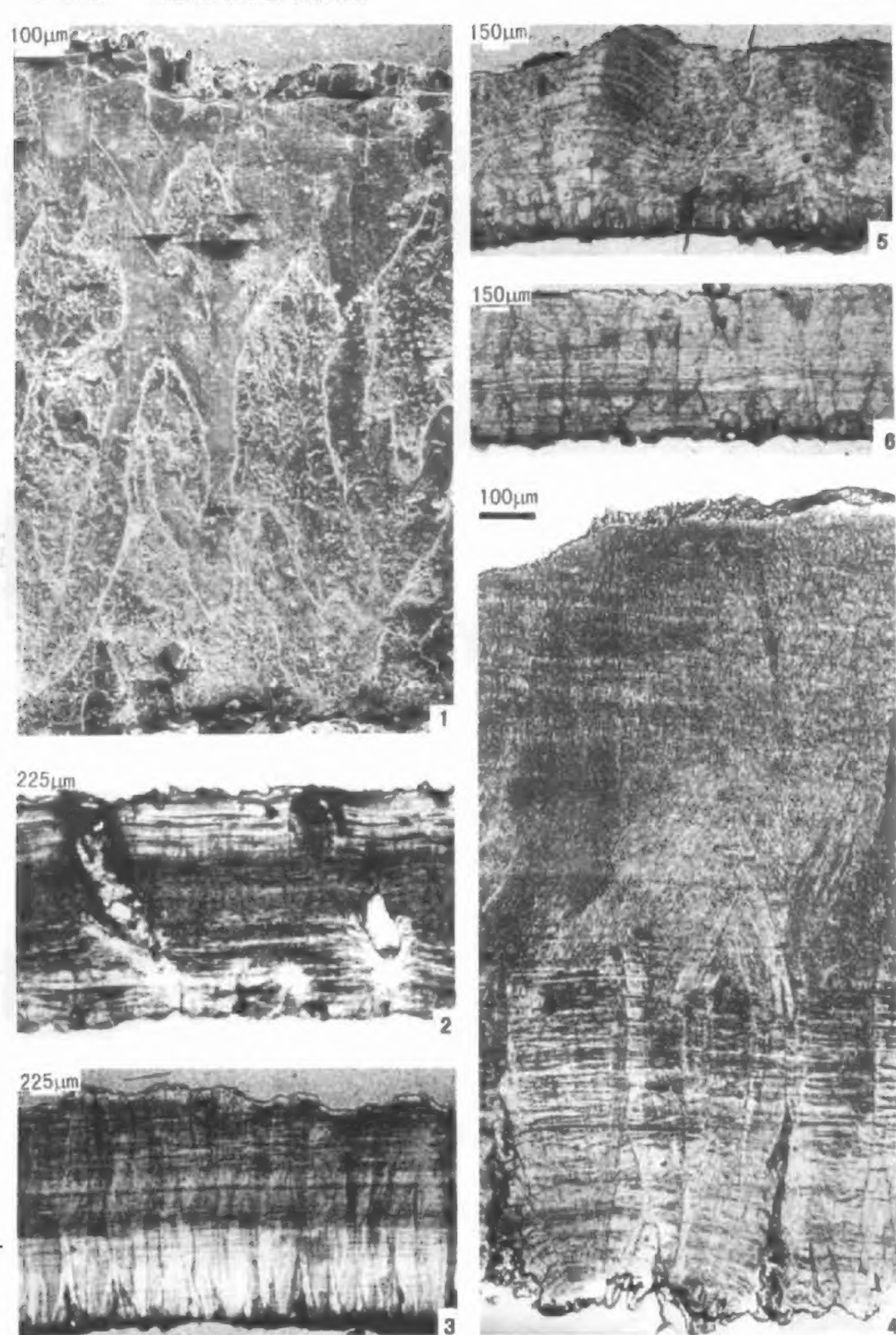
3. 径切面(正交偏光) radial view, polarized; 4. 径切面 radial view, SEM; 5. 长形蛋(未定种) (*Elongatoolithus* oosp.) 径切面(单偏光) radial view, not polarized, V11574; 6. 主田南雄蛋(*Nanhsiungoolithus chuetienensis*)径切面(单偏光) radial view, not polarized, V11576


4cm
1


100μm
2


150μm
3


150μm
4


100μm
225μm
225μm
150μm
150μm
100μm
1
2
3
4
5
6